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General Directorate for Water Resources Management

Strategy for Water and Land Resources in Iraq

Guidance Note Series

Forecasting Demand for Municipal and Rural Water Supplies and Wastewater Services

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This document is one of a series of occasional guidance notes published by the Ministry of Water Resources addressing issues relevant to strategic planning for the sustainable use of the water and land resources of Iraq.

The guidance note presents guidelines for forecasting the demand for municipal and rural potable water supplies, and also for wastewater services.

Report Issue and Revision Record

Rev	Date	Description
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1 INTRODUCTION

1.1.1 The Guidance Note presents guidelines for forecasting the demand for municipal and rural potable water supplies, and also for wastewater services. A realistic demand forecast is the essential first step in planning investments in water and wastewater facilities. Demand forecasts may be required over any time period for specific purposes but are usually required for 20 to 30 years for strategic planning purposes.

1.1.2 The present approach to demand forecasting in Iraq at present is very basic. Sometimes it appears to be little more than applying a single overall per capita demand figure combined with a rough estimate of future population. To some extent, further sophistication of the demand forecasting methodology is restricted by the availability of data, but there are some improvements that can be made now and a more complex approach will encourage planners to think in more detail about demand and also collect better data to improve assessments in the future.

1.1.3 **In this note, the approach to forecasting demand is described for each component, essentially household consumption, non-household consumption and unaccounted for water (UfW). The forecast needs to calculate the average daily demand over the year and also the peak seasonal daily demand**.

1.1.4 The average daily demand is used for assessment of revenues from water sales and the costs of production. It is also an important figure in the assessment of water resources, especially where groundwater sources are used as aquifers will generally provide adequate storage to meet seasonal peaks.

1.1.5 The peak daily demand figure is the basis for sizing abstraction, treatment and water transmission works.

1.1.6 The approach to demand forecasting presented here, and particularly any indicative levels for consumption for the various components of demand, assume the implementation of a Demand Management Policy, incorporating the actions described in the related Guidance Note – Demand Management for Municipal Water Supplies.

2 COMPONENTS OF DEMAND

2.1.1 Demand forecasts are usually built up by the following components:

- Household consumption
- Non-household consumption, which may be subdivided broadly as follows if data on different categories of consumer are readily available from the billing system:
    - Industry
    - Commerce (Offices, shops, etc.)
    - Institutions (Government bodies, schools, hospitals and religious institutions, etc.)
- Unaccounted for water, which may be subdivided as follows:
    - Physical losses from leakage in the distribution system and the service pipe to the customers' property.
    - Unregistered consumption through illegal connections and bypasses to consumer meters.
    - Connections that are not recorded and billed due to deficiencies in the water authority's billing system.
    - Under registration by consumer meters.
    - Legitimate unbilled consumption for fire fighting, mains flushing, etc.

2.1.2 The components and sub-components may be varied depending on the classification used in the billing system and may include special items related to a particular place.

3 FORECASTING DEMAND

3.1 Household Consumption

General Approach

3.1.1 Household demand is normally estimated as population served multiplied by per capita demand. Population forecasts may be based on Government official forecasts, but these may have to be extrapolated up to the water services planning horizon, which is often 20 or 25 years in the future.

3.1.2 Per capita demand may be estimated in several ways:

- From recent consumption data, extrapolating from past trends.
- An assessment from data from similar countries and regions. Data from different regions could be used to assess demands from different social groups, and under different demand management policies.
- A build up from analysis of the micro component data (drinking, cooking, bathing, clothes washing, toilet flushing, etc.). This can lead to different demands for different types of housing, sizes of households, etc. It requires detailed metering, logging and analysis of the data to determine useful factors that can be built into a regional demand forecast.

3.1.3 Per capita demand could also differentiate between metered and unmetered customers.

3.1.4 The immediate problem for Iraq is likely to the availability of reliable data on which to base an assessment of the current unrestrained consumption for different categories of customers. Only a minority of households have supplies through a working meter and the measurement of water entering the distribution system is also generally unreliable or non-existent. Under these circumstances, a basic approach is required at this stage, which may be developed further at a later date when more data become available.

Existing Consumption

3.1.5 Existing consumption is often constrained by supply and much of the data available on water consumption and population is clearly unreliable. The list of treatment works from the Ministry of Municipalities and Public Works gives actual outputs and population served, but the calculation of the per capita demand gives widely varying and, in many cases, clearly anomalous figures.

3.1.6 In areas with substantial capacity, per capita demand appears high. For example, the Basrah Mini Master Plan lists treatment plants in the governorate with a total design capacity of 695,000 m^3/d for a total population of about 1.8 million. Therefore the capacity is equivalent to over 380 lpcd. it is impossible to say what proportion of this is household consumption because losses are unknown and probably high. However, it is a large overall figure, especially because it includes all the rural population.

3.1.7 The MMPW uses a figure of 450 lpcd for the overall demand in major cities. Other plans use high figures for household demand e.g. the Basrah Mini Master Plan uses 300 lpcd in Basrah and 200 lpcd elsewhere, including rural areas. For Basrah city, the per capita household demand translates into an overall figure of 432 lpcd including UfW equivalent to 20% of consumption. Other plans use similar figures for overall demand e.g. The New Eden Project uses 450 lpcd for governorate capitals and 360 lpcd for district capitals, and the mini master plans for Erbil and Sulamaniyah also use 360 lpcd for district capitals.

3.1.8 The mini master plans, the New Eden Project and MMPW all use a single figure for demand. There is no reference to seasonal variations and no data on such variations, although we would expect demand to be substantially higher in the hot summer months.

Future Demands

3.1.9 We believe that the **there should be an active demand management policy in Iraq** as outlined in the Guidance Note – Demand Management for Municipal Water Supplies. This should include raising tariffs to recover as much as possible of the total cost of supplying water, within the limits of people's affordability. We believe this will constrain winter demands to the levels in Europe and Muscat (See Guidance Note on Demand Management), whilst there may be an increase in the hot summer months. On this basis, we would expect the demand in winter to be about 130 to 140 lpcd, increasing in the summer by, say, 25 lpcd to allow for extra washing and bathing. In addition, in the main towns it is necessary to allow for the use of air coolers in the summer. From discussions with Iraqi visitors, we understand that water consumption by air coolers amounts to between 25 and 50 lpcd and 90% of homes in Baghdad would use them. From this we assume that the household consumption in the main towns may be estimated as follows:

- Winter consumption, 6 months at 135 lpcd
- Summer consumption, 6 months at 160 lpcd (excluding air coolers)
- Additional use for air coolers, 4 months at 40 lpcd.

3.1.10 This gives an average annual consumption of about 160 lpcd, with a summer peak of 200 lpcd.

3.1.11 For rural areas we would expect there to be less internal plumbing in the houses and much less use of air coolers in the summer. We believe that it would be reasonable to assume:

- Winter consumption, 6 months at 100 lpcd

- Summer consumption, 6 months at 125 lpcd (excluding air coolers)
- Additional use for air coolers, 4 months at 20 lpcd.

3.1.12 This gives an average annual consumption of about 120 lpcd, with a summer peak of 150 lpcd.

3.1.13 Clearly these are preliminary estimates based mainly on international experience and hearsay evidence. However, we believe that they are reasonable figures to be used as a starting point. **They may be viewed as preliminary figures, which should be refined by those responsible for planning water supply systems in Iraq as more data on actual consumption is collected**.

3.1.14 One aspect that is not included in the above is garden watering. We understand that in Baghdad there is a separate non-potable water supply network that distributes untreated water, primarily for garden watering. In general, the use of potable water for irrigation of any form is to be discouraged, although some garden watering is to be expected, and can be a very efficient means of irrigation as it will usually provide only the water required and often be used for high valuable vegetable crops. In Baghdad the garden watering network should be considered separately. Elsewhere, it may be necessary to add in an allowance for garden watering for part of the year. This will increase the peak demands.

3.2 Non-household Consumption

3.2.1 Non-household consumption can only be assessed from billing records for metered supplies. Unfortunately, only a minority of connections presently appear to be metered. Data from Baghdad municipality indicates that only 21% of industrial and commercial connections are metered and no connections to government offices and institutions are metered. For medium sized non-industrial towns, non-household consumption might be taken as about 25% of household consumption as a first estimate. For small towns and villages, non-household demand is usually low, unless there is a single major industrial or institutional water user based there and which is disproportionate in size to the resident population. In Baghdad non-households account for about 35% of the total number of connections, many of which would be expected to have a much higher consumption than the average household. This would suggest that non-household demand is at least 50% of household demand in Baghdad. However, the figures may be misleading. Firstly, there is an average of about 16 persons per household connection, suggesting that some connections serve several households, presumably single connections to a block of flats. There are many government connections, which suggests that some may be to government housing, that is they are in effect household connections although categorised as non-household. The demand from any connections to residential buildings should be included in the calculation for household demand.

3.2.2 A further complication is the presence of major residential institutions such as military camps and hostels for students, etc. If the people living in these institutions are included in the census, there is a danger of double counting them – both as household demand and non-household. If they are in the census population, and therefore included in the population for the purpose of estimating household water demands, they should be excluded from projections of non-household demand.

3.2.3 Major industries will often have their own separate private water supply, but any large water users that take water from the public supply, say using more than 0.5% of the total water supply, should be included separately and in addition to any overall allowance for non-household consumption.

3.2.4 As a first estimate of non-household demand we propose that it should be taken as a percentage of household demand, but varied according to the type of town and with special allowances for major industries and large residential institutions, where people are not included in the population for the purposes of estimating household demand. Preliminary proposals for estimating non-household demand are:

Baghdad	50% of household demand plus identified major consumers
Other towns	25% of household demand plus identified major consumers
Rural areas	10% of household demand plus identified major consumers

3.2.5 There is an urgent need to reassess non-household demand and this requires metering of all non-household connections. There should also be clarity on the rules concerning the gathering of census data, in particular whether people in residential institutions are included.

3.2.6 Peak seasonal demand factors are usually less for non-household than household supplies. Where there is no data to allow an assessment of peak factors in a particular town, it is suggested that the peak summer demand be taken as 110% of the average demand.

3.3 Unaccounted for Water

3.3.1 Unaccounted for water (UfW) is the difference between the volume of water put into the distribution system and that which is charged for. UfW comprises:

3.3.2 Physical losses from leakage in the distribution system and the pipework taking the supply into the customer's house.

- Commercial losses, which comprise:
    - Unregistered consumption through illegal connections and bypasses to consumer meters
    - Connections that are not recorded and billed due to deficiencies in the water authorities billing system
    - Under registration by consumer meters
    - Legitimate unbilled consumption for fire fighting, mains flushing, etc.

3.3.3 Further details of UfW and how to control it are given in the Guidance Note – Demand Management for Municipal Water Supplies.

3.3.4 Existing levels of unaccounted for water are unknown because of the lack production meters and consumer meters. It is believed that losses are large because much of the distribution pipe is in poor condition and in many places has been damaged in recent conflicts.

3.3.5 A priority, wherever the security situation allows, should be the control of leakage from the system and reduction of UfW. An appropriate target figure for UfW is 25% of water distributed. This is not a demanding target, and could be set lower in the future.

3.3.6 The first requirement will be the installation of production meters on all treatment plants and metering of all non-household consumers. Household consumers should also be metered as soon as is practicable. This will allow an assessment of the overall level of UfW. This will be followed by the establishment of District Meter Areas (DMAs), monitoring of night flows, leak detection and repair programmes and other actions necessary to minimise UfW.

3.3.7 In the absence of any reliable data, it is proposed that UfW should be provisionally assessed at 40% of production at present reducing to 25% by say 2015.

3.3.8 Whilst the measurement of UfW as a percentage of water production is still the commonest form of presenting the figure, it is generally not considered the best means of comparing rates. Water companies are now tending to present UfW in terms of litres per connection per day or cubic metres per kilometre of distribution main per day. A standard measured in these terms reflects the fact that most leakage occurs at consumer connections and on the customer's supply pipe, and then from joints in the distribution pipework. It is recommended that water authorities in Iraq adopt such standards when data is available. A suitable target figure would be 150 litres per connection per day or 12 m^3 per kilometre of distribution main per day.

3.4 Summary of Provisional Estimates of Per Capita Demand

3.4.1 Provisional proposals for per capita demands to be used in developing future demand forecasts are presented in the table below.

Table 3-1 : Provisional Forecasts of Per Capita Demands

Baghdad		
Category	Average daily demand (lpcd)	Peak daily demand (lpcd)
Households	160	200
Non-households (See Note 1)	80	88
UfW	80	80
Total	320	368
Other towns		
Category	Average daily demand (lpcd)	Peak daily demand (lpcd)
Households	160	200
Non-households (See Note 1)	40	44
UfW	67	67
Total	267	311
Rural communities with piped distribution		
Category	Average daily demand (lpcd)	Peak daily demand (lpcd)
Households	120	150
Non-households (See Note 1)	12	13
UfW	44	44
Total	176	207

Note: 1. Specific large industries and residential institutions to be added separately to the overall allowance

3.4.2 No allowance is made for changes in per capita consumption over time. It is expected to reduce towards the levels in the above table as demand management measures, including customer metering and tariff increases, are implemented.

3.4.3 **These are only provisional figures and it is important that each water service provider develops its own demand forecast based on actual data, which will require the installation of new meters on many treatment works and extension of consumer metering**

4 WASTEWATER FLOWS

4.1 Options for Wastewater Treatment and Disposal

4.1.1 Wastewater is normally either delivered to the public sewer or treated on site. For households without a connection to the sewer, wastewater is likely to be discharged to a septic tank and the overflow passes to a soakaway and thence to the groundwater table. In some areas the overflow may be delivered to surface drains, although since the overflow still has considerable oxygen demand this is not an environmentally satisfactory solution and may lead to unpleasant odours and transmission of disease. In Iraq at the present time it is clear that much wastewater is discharged to open drains, with a consequential impact on the environment. Septic tanks, provided they are well designed, should operate for a few years before the sludge builds up to a point where it needs to be removed. Industries and large institutions may have their own treatment plants and discharge treated wastewater to the river.

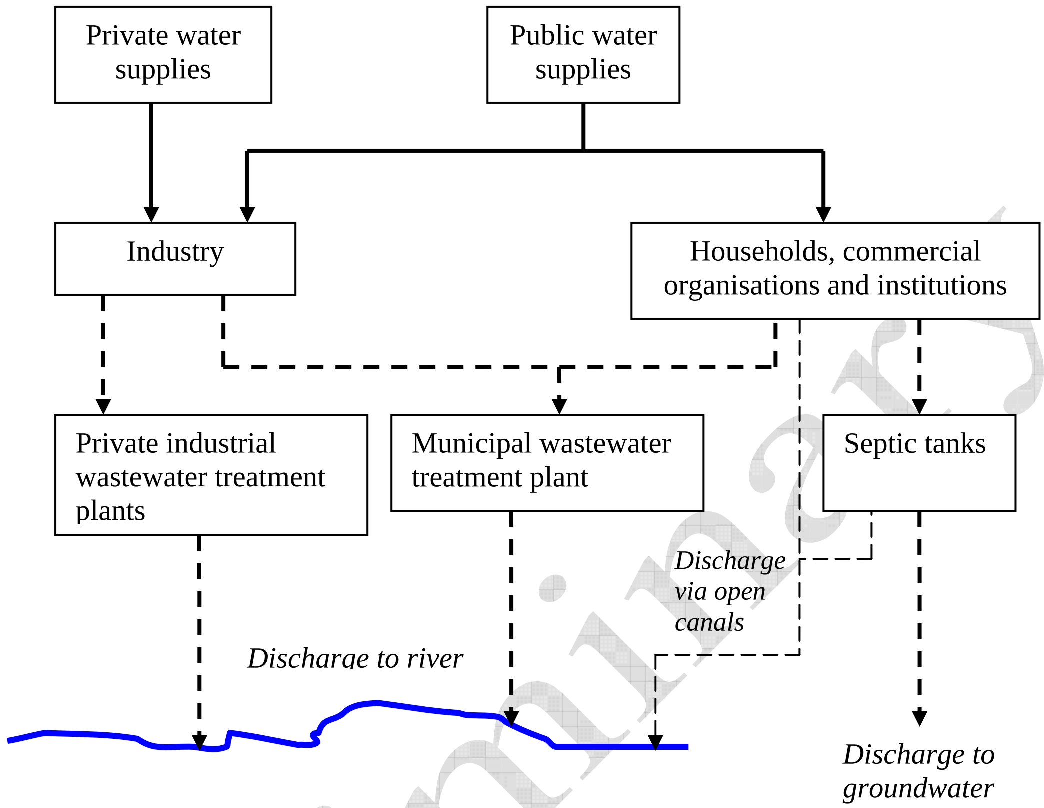
4.1.2 In assessing wastewater flows, it is first of all necessary to understand the treatment and disposal options available and assess:

- The number of household, commercial and institutional customers discharging wastewater to the sewerage system
- The number of household, commercial and institutional customers discharging wastewater to septic tanks
- Industries with connections to the public water supply which also discharge their wastewater to the public sewers
- Industries with connections to the public water supply which treat and discharge their wastewater to the environment
- Industries with private water supplies but which discharge their wastewater to the public sewers.

4.1.3 The above options for wastewater treatment and disposal are shown diagrammatically in Figure 4-1.

4.1.4 Septic tanks offer the most economic method of treatment and disposal of wastewater for small towns and villages where the density of population is reasonably low, the water table is more than five metres below the surface and the underlying strata is permeable. In much of Iraq the water table is high and the long term aim is likely to be the installation of piped sewerage systems in most towns. However, at present very few towns have an extensive sewer network, and even fewer have an adequately sized fully operational sewage treatment plant.

Figure 4-1 : Wastewater Treatment and Disposal Options



4.2 Estimation of Sewage Flows

Household Wastewater

4.2.1 Sewage flows are estimated as a percentage of water consumption. The wastewater discharged to sewers or septic tanks from households is usually about 80% to 90% of water supplied, the remainder being lost to evaporation from house cleaning, yard cleaning, plant watering, etc. In calculating wastewater generation in Iraq, it will be necessary to exclude the water consumption by air coolers and any major garden watering from overall water use as these may be substantial volumes of water supplied which are not returned to the sewer.

4.2.2 A preliminary assessment of the wastewater volumes likely to be generated in urban and rural areas is presented in Table 4-1. In the table the returns to wastewater are assumed to be 90% of water supplied in winter and 85% in summer, allowing for small scale garden and house plant watering and generally higher evaporative losses. The table includes the water used for air coolers, but no large scale garden watering, which would not contribute to wastewater flows.

4.2.3 Household wastewater generation is estimated to be an average of 129 lpcd in urban areas and 116 lpcd in rural areas. Peak flows are estimated to be 136 lpcd in urban areas and 123 lpcd in rural areas. As with water demands, these figures are preliminary estimates and need to be reviewed when better data is available.

Table 4-1 : Preliminary Calculation of Per Capita Wastewater Flows

Location/consumption category	Average demand lpcd	Waste-water %	Waste-water lpcd
Urban areas			
Household use winter (6 months)	135	90%	122
Household use summer	160	85%	136
Air coolers (4 months)	40	0%	-
Average water use/wastewater return	161	80%	129
Rural Areas			
Household use winter (6 months)	120	90%	108
Household use summer	145	85%	123
Air coolers (4 months)	20	0%	-
Average water use/wastewater return	139	83%	116

Non- household Wastewater Flows

4.2.4 Non-household wastewater flows will be about 90% of water supplied for commercial and institutional customers. Industrial wastewater will depend on the nature of the industry and large firms must be considered individually. The volume discharged to public sewers and the environment will depend on whether it treats all or part of its own wastewater. In calculating the requirements for sewerage and sewage treatment, it is also necessary to allow for industries that have their own water supply, but return wastewater to the public sewers.

Calculation of Wastewater Flows to Treatment Plants

4.2.5 The sewage flows to wastewater treatment plants in urban areas will be calculated as follows:

Average daily flow $= (P \times N_p \times 129)/1000 + C \times Nc + I_a$

Peak summer flow $= (P \times N_p \times 136)/1000 + C \times 1.1 \times Nc + I_p$

Where the flows are in m^3/d and:

P = Total population

N_p = Percentage of total population connected to the sewer network

C = Average consumption by commercial, institutional and small industrial customers in m^3/d

N_c = Percentage of commercial, institutional and small industrial customers connected to the sewer network in m^3/d

I_a = Average discharge from major industries in m^3/d

I_a = Peak summer discharges from major industries in m^3/d

4.2.6 In addition to the above sewage flows it will be necessary to add:

- Infiltration to sewers from the groundwater. In areas where the groundwater table is high infiltration is often substantial, especially if sewers are old and/or in poor condition. In these circumstances infiltration may be as much as 50% of the total flow in the sewers. The volume of infiltration can only be determined by measurement of flows.
- Stormwater flows. Even where there are separate foul sewers and stormwater drains some rain water will enter the foul sewers from roof drainage, via open manholes, etc. This can only be determined by measurement of flows in the field.

4.2.7 Whilst infiltration and stormwater flows are very important factors in the design of the sewer system and treatment plants, from the point of water resources they only have a small localised impact on run off to rivers and the transfers between groundwater and surface water.

5 EXAMPLE OF DEMAND CALCULATION

5.1.1 An example of a calculation of water demands and volumes of wastewater generated is presented in the table below. This is only included as an example and will need to be modified for actual data and adapted to different locations. The table has been developed using the criteria presented above. An overall figure of 85% of water consumption has been used to estimate returns to sewers.

Table 5-1 : Example of Forecast of Water Demand and Wastewater Generation

District: Nasariyah

		Year				
		2005	2010	2015	2020	2025
Population (See Note 1)						
Urban	Nr	423,897	491,413	569,683	660,418	765,606
Rural	Nr	134,378	155,781	180,593	209,356	242,701
Population served as % total						
Urban	%	90%	100%	100%	100%	100%
Rural	%	0%	100%	100%	100%	100%
Average per capita water demands						
Urban	(lpcd)	160	160	160	160	160
Rural	(lpcd)	120	120	120	120	120
Unaccounted for water	%	40%	25%	25%	25%	25%
Average daily water demand						
Urban households	m3/d	61,041	78,626	91,149	105,667	122,497
Rural households	m3/d	-	18,694	21,671	25,123	29,124
Non-household (Note 2)	m3/d	12,860	20,372	23,999	28,204	33,078
Major industry	m3/d	2,400	2,400	2,400	2,400	2,400
UfW	m3/d	50,868	40,031	46,407	53,798	62,366
Total average day	**m3/d**	**127,169**	**160,123**	**185,626**	**215,191**	**249,466**
Peak daily water demand						
Urban households	m3/d	76,302	98,283	113,937	132,084	153,121
Rural households	m3/d	-	25,704	29,798	34,544	40,046
Non-household (Note 2)	m3/d	14,146	22,409	26,399	31,024	36,386
Major industry	m3/d	2,400	2,400	2,400	2,400	2,400
UfW	m3/d	50,868	40,031	46,407	53,798	62,366
Total average day	**m3/d**	**143,716**	**188,827**	**218,940**	**253,850**	**294,319**
Flows to WWTP						
Population connected						
Urban	%	25%	35%	50%	75%	100%
Rural	%	0%	0%	0%	0%	0%
Non households connection						
Urban	%	25%	50%	80%	100%	100%
Rural	%	0%	0%	0%	0%	0%
Average sewage flow to WWTP						
Urban households	m3/d	12,971	23,391	38,738	67,363	104,122
Rural households	m3/d	-	-	-	-	-
Urban non-household	m3/d	2,733	7,334	13,863	20,414	23,991
Rural non-households	m3/d	-	-	-	-	-
Industry	m3/d	2,040	2,040	2,040	2,040	2,040
Total sewage flow	**m3/d**	**17,744**	**32,765**	**54,642**	**89,817**	**130,153**
Infiltration	m3/d	Determine from field measurements				
Total average DWF	**m3/d**	**= sewage flow + infiltration**				

1 Population assumes growth rate of 3% per annum

2 Non-household demand assumed to be 25% of household in urban areas, 15% in rural areas